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SUBJECT: TrU - Proposed Rates for Operational Release of Radioactive Materials to the Atmosphere

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ABSTRACT

Downwind air concentrations and ground depositions resulting from proposed rates of release of radioactive gases and aerosols from TrU operations are reported.

TrU - Proposed Rates for Operational Release of Radioactive Materials to the Atmosphere

Small quantities of radioactive gases and aerosols will be released through vessel, cubicle, and glove box ventilation systems to the HFIR stack during routine operation of TrU. Maximum anticipated release rates for these gases and aerosols have been calculated using maximum inventories of these materials and conservative efficiencies for ventilation cleanup devices. Maximum downwind air concentrations and ground deposits have been evaluated for the maximum release rates using meteorological calculational techniques which have been demonstrated to be accurate within a factor of two. These calculated concentrations and depositions are considered to be well within the present permissible levels and, in general, are small fractions of the concentrations and depositions that presently exist at ORNL due to present activity release rates.

Present design concepts for TrU are based on the assumption that the maximum anticipated activity release rates will be acceptable approximately CY-1967 after two years of operation of TrU at slowly increasing release rates. If permissible levels of activity are lower at that time and are not compensated by lower than calculated release rates, as determined by practice, it will be possible, through a loss in convenience and production capacity, to lower the maximum release rates. Typical procedures for lowering the release rates would include installation of charcoal traps in appropriate off-gas systems, provision for increased decay time prior to processing of targets, storage of spontaneously fissioning isotopes in a solid form, and minimization of aerosol-producing operations.

Off-Gas Systems

Of the types of activity to be released from TrU, essentially all of the rare gases and halogens and most of the aerosol will pass through the vessel off-gas system, which exhausts through a caustic scrubber (DF = 18 for halogens), a roughing filter, and double absolute filters, to the HFIR stack. The removal rate from vessels generating short-lived fission products will be 1.67×10^{-4} sec^{-1}. The remainder of the aerosol release is primarily through the cubicle ventilation system with a small portion being released through the glove box ventilation system. Both of these latter systems exhaust to the HFIR stack through roughing and double absolute filters.

The HFIR stack is located in Melton Valley approximately one mile southeast of the X-10 area in Bethel Valley. The stack height is 250 ft and the elevation of the base is 835 ft above sea level. The diameter of the top of the stack is 5 ft. The stack is designed to have an air flow rate of 60,000 cfm and the normal temperature of the air will be 130°F.

Atmospheric Dilution and Deposition Factors

Atmospheric dilution and deposition factors for the HFIR stack are tabulated in Table 1. The maximum value of maximum average dilution factor was calculated for occupied elevations of less than 900 ft by balancing the effects of wind speed and plume rise. The deposition factors were evaluated for small particles which behave as gases using an experimentally determined[1] deposition velocity of 0.02 meters/sec. The average annual dilution and deposition factors were determined using the methods of Culkowski.[2]

It should be noted that the average annual concentrations and depositions will be approximately a factor of three lower in Bethel Valley than at the location of the annual maxima, approximately 1.5 miles E-NE of the stack.

Effects of Release of Gases and Aerosols

The effects of operational releases of radioactive gas and aerosol from TrU are tabulated in Table 2. The radioactive elements originate in batch dissolution of HFIR targets, spontaneous fission of Cf, and handling operations.

Dissolution of HFIR Targets. Dissolution of a long-irradiated, short-cooled target could result in the release of 1.3 curies Kr-85, 40 curies Xe-133, and 18 curies I-131 to the vessel off-gas system over a several minute period. Such a dissolution possibly will average once per two week period. Since the xenon and krypton are released at a rate of approximately 0.1 curie/sec, the average ground dose rate during the time of the release would be approximately 0.25 mr/hr with short duration peak dose rates of no more than 25 mr/hr. This release rate of rare gas is within established practice. For example, the Brookhaven and X-10 reactors continuously release 0.15 and 0.058 curies/sec, respectively, of A-41.

No more than one curie of the I-131 in a target will survive the caustic scrubber and filter system to result in a maximum release rate, over the several minute period of release of 2.5×10^{-3} curies/sec and an average annual release rate of 0.07 curies/day. During the several minute period of release the maximum average downwind concentration will be $2.5\ (MPC)_{a\text{-}40}$. The maximum ground concentration averaged over a period of a year will be approximately $10^{-4}(MPC)_{a\text{-}168}$. Since one curie of I-131 will be available in the atmosphere for a short term deposition, the maximum deposit at any given time will be equivalent to 4400 d/min-100 cm^2. Deposits due to average annual buildup will not exceed 50 d/min-100 cm^2.

The release rate of I-131 is also within established practice. The ORNL 3039 stack and Hanford separations stack[4] continuously discharge 0.2 and 1.0 curies/day, respectively, of I-131. Using the same methods of calculation that have been used in the preparation of this report, it may be concluded that the equilibrium I-131 level from the ORNL-3039 release is 2.3 curies and, therefore, the maximum ground deposition in Bethel Valley approaches 10,000 d/min-100 cm^2.

Table 1. Dilution and Deposition Factors for HFIR Stack

	Dilution Factor $\frac{\text{curies/M}^3}{\text{curie/sec}}$	Deposition Factor $\frac{\text{curies}}{\text{M}^2\text{-curie released}}$
1. Maximum Average, max. value over several minutes to several hour period of unchanging weather conditions	1.0×10^{-5}	2×10^{-7}
2. Peak, peak values of short (few second) duration representing maxima of statistical fluctuation	$\sim 10^{-3}$	Not Important
3. Maximum Average Annual. Max. value averaged over yearly weather conditions (occurs ~1.5 miles E-NE of stack).	2×10^{-7}	6×10^{-9}
4. Average Annual In X-10 Area, Bethel Valley	4×10^{-8}	2×10^{-9}

Table 2. Effects of Operational Release of Radioactive Gas and Aerosol from TRU

Source and Type of Release	Activity Release Rates			Downwind Ground Dose Rate or Concentration			Ground Deposition			
	Type of Activity	Maximum Release Rate	Average Annual Release Rate	Max. Avg.[1]	Peak[2]	Max. Avg.[3] Annual	Maximum[1] d/min-100 cm^2	Maximum[1] mrep/hr	Max. Avg. Annual[3] d/min-100 cm^2	Max. Avg. Annual[3] mrep/hr
Batch Dissolution of HFIR Target (Occurs Once Every Two Weeks) Releases 40 curies Xe-133 and 1 curie I-131 over several minute period.	Xe-133	0.1 curies/sec	1000 curies/yr, 3.2 x 10^{-5} curies/sec	0.25 mr/hr	25 mr/hr	10^{-6} mr/hr	-	-	-	-
	I-131	2.5 x 10^{-3} curies/sec	0.07 curies/day, 8.3 x 10^{-7} curies/sec	2.5 times $(MPC)_{a-168}$	-	10^{-4} times $(MPC)_{a-168}$	4400	0.14	50	0.002
Continuous Release of Rare Gas Fission Products by 100 units of spontaneous fission in Cf (Removal rate before filtration [illegible] x 10^{-4} sec^{-1})	Xe . Kr Xe + FF's	0.0025 curies/sec	0.0025 curies/sec	0.05	5	0.001	5000 Predominantly Cs-138	0.15	8 73% Cs-137 20% Sr-89 1.1% Sr-90 2.0% Y-91 3.6% Ce-141	0.00025
"Continuous" Production of Actinide and Fission Product Aerosols by Handling Operations	Alpha-emitting Actinides. Traces with Pu-242, Cm-244, or Cf-252	1[illegible] microcuries/day	1[illegible] microcuries/day	0.2% $(MPC)_{a-168}$	-	0.005% $(MPC)_{a-168}$	-	-	4.9	-
	Non-volatile FP's 1 d< $T_{1/2}$ < 1 yr	1000 microcuries/day	1000 microcuries/day	4 x 10^{-5} mr/hr	0.004 mr/hr	-	270	0.006	60	0.0025

1) Maximum value over several minutes to several hour period of unchanging weather conditions.
2) Maximum value of very short duration peaks of statistical fluctuations.
3) Maximum value averaged over yearly weather conditions.

Release from Spontaneous Fission. Using Cf-252 fission yield data,[3] the continuous rate of release of radioactive rare gases resulting from spontaneous fission of the californium in storage within the facility will not exceed 0.0025 curies/sec. These gases will cause a maximum average downwind dose rate of 0.05 mr/hr with peak dose rates of approximately 5 mr/hr. The short-term maximum deposit will not exceed 5000 d/min-100 cm^2, predominantly from Cs-138, and the average annual ground deposit from long-lived isotopes will not exceed 8 d/min-100 cm^2, predominantly from Cs-137 and Sr-89.

In the deposition calculations it was assumed that solid fission products formed by decay of rare gases prior to filtration would remain in the system due to impingement on the solution in the tank, the walls of the tank, and the filters. This effect causes 80% of Cs-138 and 95% of Cs-137 and Sr-89 to be retained in the off-gas system.

Aerosol Release

Examination of aerosol formation mechanisms has revealed that the continuous release rates of aerosols of alpha emitters and fission products will not exceed 10 and 1000 microcuries/day, respectively. The $(MPC)_{a-40}$ for credible alpha emitter and fission product distributions to be encountered in TrU was determined to be 1.5×10^{-12} and 6×10^{-9} curies/M^3, respectively. The maximum deposit of long-lived alpha emitters after 10 years of operation of TrU will be equivalent to 4.9 d/min-100 cm^2. The maximum deposit of fission products, built up over the same period will be equivalent to 80 d/min-100 cm^2.

The most notable precedents for aerosol release occur at the Hanford plant where alpha emitters, presumably Pu-239, and fission products are released at rates of 30 microcuries/day and several millicuries/day, respectively.[4]

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REFERENCES

(1) W. M. Culkowski, personal communication, 1/25/62.

(2) W. M. Culkowski, "Estimates of Accumulated exposures and Environmental Build-up of Radioactivity," paper presented at Sixth AEC Air Cleaning Conference.

(3) E. K. Hyde, "A Review of Nuclear Fission," UCRL-9036, pp. 161-163.

(4) R. E. Tomlinson, "Radiochemical Plant Containment at Hanford," Nuclear Safety, Vol. 3, No. 1, pp. 51-56.